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A Discussion Paper on Flood Plain Management Alternatives in Ontario

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*This volume was donated to
the University of Toronto by
Derek J.W. Little
President, Municipal Planning
Consultants Co. Ltd.*

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August, 1977


During recent years, support to review the province's flood plain criteria and management policy has increased. Concern has been expressed that areas defined as "flood plain" under existing criteria are too large and policies which regulate development in those areas of the flood plain which can expect only shallow flooding, have become economically unjustifiable, particularly in light of rapidly increasing land values over the past five or six years. In addition, some municipalities have stated that more flexibility is needed in the application of flood plain criteria in order that unique local situations can be recognized.

Against this desire by some to generally relax present flood plain criteria, one must place the rather sobering event of the 1974 Grand River flood. Although this flood caused in the neighbourhood of \$7,000,000 damages, it did not extend to the limits of the area defined as "flood plain" under the existing criterion.

Another realization, shared by the province, the conservation authorities, and municipalities, is the need to integrate land use and water management planning at the local level. The need for such integration is most obvious in those areas where the pressures of urban growth are the greatest.

In response to these concerns and in recognition of the increasing sophistication of evolving flood plain management techniques, the Ministry of Housing and the Ministry of Natural Resources commissioned the consulting firms of M. M. Dillon and James F. MacLaren Limited to undertake a comprehensive Flood Plain Criteria and Management Evaluation Study.

The consultants have completed their work and have provided about 1,000 pages of technical working papers. This information has been condensed in a summary report entitled The Flood Plain Criteria and Management Evaluation Study, (attached).



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The technical working papers are available for review in the Queen's Park Libraries of the Ministry of Natural Resources and the Ministry of Housing, and also are available on an inter-library loan basis. Sets of these working papers are available for review in regional offices of the Ministry of Housing in Toronto, Ottawa, Sudbury, Thunder Bay and London, and the regional offices of the Ministry of Natural Resources in London, Richmond Hill, Kemptville, Huntsville, Timmins, Sault Ste. Marie and Thunder Bay. Copies of the consultant's Summary Report are available through the Ontario Government's Bookstore.

After reviewing draft copies of the documents prepared by the consultants, Mr. Bernier, my predecessor, and Mr. Rhodes, directed the Steering Committee assigned to the study to prepare a discussion paper which would clearly focus on the problems, issues and alternative approaches to flood plain management. This paper was to be prepared on the basis of the consultants' reports, as well as the experience of those on the Steering Committee. In particular, the Steering Committee was asked to include in the discussion paper a set of proposed recommendations regarding what they believed to be the most preferable approach to flood plain management in Ontario.

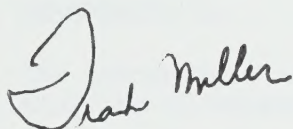
The most significant of the recommendations made by the Steering Committee relate to the proposed application of the "two zone floodway-flood fringe" concept in cases where certain conditions are met. Under the two zone concept, development would be permitted in the fringe of the flood plain if special flood protection measures were adopted. Development would not be permitted in the floodway i.e. the danger zone of the flood plain where deep and fast flowing waters would cause loss of life and severe damage to property. Present criteria used to define the flood plain in various areas of the province would remain in effect.

On behalf of Mr. Rhodes and myself, I invite you to comment on this Discussion Paper and, in particular, the recommendations contained within. I also would welcome any recommendations that you may wish to make. Only by receiving comments from those groups and individuals with an interest in the topic, can we evaluate the suitability of these recommendations as the basis for a revised provincial flood plain management policy.

Additional copies of the Discussion Paper are available from the Ontario Government's Bookstore.

By December 15, 1977, please forward your comments and enquiries to:

Policy Co-ordination Secretariat
Ministry of Natural Resources
Room 6508, Whitney Block
Queen's Park
Toronto, Ontario
M7A 1W3

A handwritten signature in black ink, appearing to read "Frank S. Miller". The signature is written in a cursive style with a large, stylized initial "F".

Frank S. Miller
Minister

Attachment



Ministry of
Natural
Resources

Your file:

1977 06 21

Our file:

MEMORANDUM TO:

The Honourable Frank S. Miller
Minister of Natural Resources

The Honourable John Rhodes
Minister of Housing

SUBJECT: Discussion Paper
Flood Plain Criteria and Management Study

I take pleasure in transmitting to you the discussion paper on the Flood Plain Criteria and Management Evaluation Study. This paper is based on the Summary Report and the Technical Working Papers presented to the two ministries by the consulting firms of James F. MacLaren Limited and M. M. Dillon Limited who were engaged to carry out the study.

A handwritten signature in cursive script, reading "A. D. Latomell".

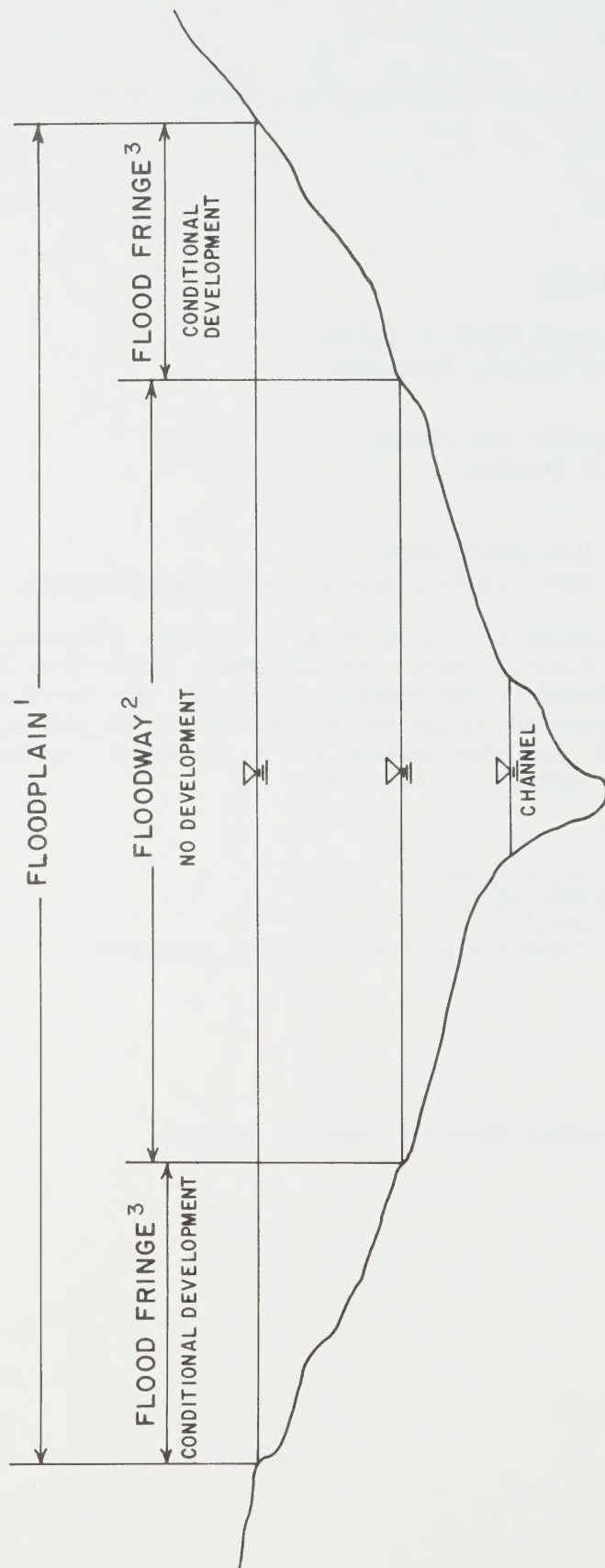
A. D. Latomell
Chairman, Flood Plain Study Steering Committee

and

Deputy Regional Director, Central Region

ADL/gc
Attach.

THE TWO-ZONE FLOODWAY - FLOOD FRINGE CONCEPT



1. The floodplain would be defined by the Hazel flood, the Timmins flood or the 1 in 100 year flood, depending upon the location in the Province. (See map on page 16)
2. Floodway is defined as the danger zone in which no building or filling to be permitted.
3. Flood fringe is the area, where filling and development may be permitted if special flood protection measures are adopted.

Figure 1

Conclusions and Recommendations

1. That individual municipalities be given increased scope to permit more intensive land uses in the fringe areas of their flood plains through the adoption of the two zone floodway-flood fringe concept provided that:
 - (i) The municipality can show to the local conservation authority, or to the Ministry of Natural Resources (for areas where no conservation authority exists), through hydrologic and hydraulic analyses that such development will not significantly and adversely affect other municipalities in the watershed.
 - (ii) The municipality develops and adopts an Official Plan and zoning bylaws supported by information which shows that development in the "flood fringe" is essential to the future social and economic well being of the community and that present and permitted future land uses will not be subject to unnecessary risk of flood damage.
 2. That flood plains in Ontario be based on the one in 100 year flood or the regional flood, whichever is greater. Individual municipalities should have the option of adopting a higher level of protection if they wish.
 3. That the term "flood plain" be used in Official Plan designations for flood prone areas rather than the more general term "hazard land".
 4. That land uses which are permitted in the flood plain be clearly defined in Official Plan policies and zoning bylaws.
 5. That a specific definition of "flood plain" be included in Section 1 of The Conservation Authorities Act and that such a definition be cross-referenced in The Planning Act.
 6. That a municipality be given the option of being exempted from construction and filling regulations under The Conservation Authorities Act, once it has adopted similar control procedures through zoning bylaws. Once an exemption is given, the conservation authority (or the Ministry of Natural Resources) would be notified of all proposed amendments.
 7. That the provision of flood-proofing measures to regulate the design and construction of structures erected in the flood fringe be incorporated into the Ontario Building Code.
 8. That flood plain mapping programs be accelerated to cover all major watersheds in Ontario. All future programs which include the mapping of flood plains should comply with the base mapping standards adopted by the Surveyor General of Ontario.
 9. That present and future property owners and tenants of the flood plain should be clearly informed of the risk of damage to which they are susceptible.
- In addition to these specific proposals, it should be recognized that the level of sophistication of flood plain management is rapidly evolving and that continuing effort must be directed towards:
- (i) Explaining the objectives and basic concepts related to flood plain management;
 - (ii) Integrating flood plain management decisions within over-all land use and resource management plans of individual watersheds;
 - (iii) Developing the capability to more accurately predict flood flows for individual watersheds through gauging of stream flows and the application of more sophisticated hydrological prediction techniques;
 - (iv) Explaining the "two zone floodway-flood fringe" concept and the implications of adopting this concept on increased flood flows; and
 - (v) Explaining flood proofing techniques necessary for development in the flood fringe.

1. Introduction

THE main objectives of current flood plain management policy in Ontario are to eliminate loss of life and to minimize flood damages to existing and new developments. In some cases where little threat to life appears to exist, current policies which limit the types of new developments permitted in flood plains are challenged as being economically unjustified; that is, the value of development opportunities being lost is seen to be greater than is the risk of damage to such development. Escalating land values and their effect on housing prices appears to be the main reason for recent concerns.

In response to these concerns, the Ministry of Natural Resources and the Ministry of Housing commissioned the consulting firms of M. M. Dillon and James F. MacLaren Limited to undertake a flood plain criteria and management evaluation study. The facts and observations from this study, and the experience of the two ministries, form the main bases for the following paper.

2. A Perspective on Flooding in Ontario

THE magnitude of flooding problems in Ontario is demonstrated by the fact that 430 floods were reported in the 20-year period from 1950 to 1970. In 1954, Hurricane Hazel caused more than \$75,000,000 in damages and more than 80 deaths. A more recent flood in the Grand River Watershed in 1974 caused \$7,000,000 damages, not including business losses.

Newspaper records from 1950-1970 indicate that 65% of flood damages have been incurred by the residential sector, 25% by the commercial sector, and the remainder by industrial and institutional land users.

A rough estimate of the average distribution of land uses within Ontario's urban flood plains is:

Residential.....	14%	Open Space.....	25%
Commercial.....	3%	Vacant or	
		Agriculture.....	40%
Industrial.....	8%		
Institutional.....	5%	Other.....	5%

An analysis of the reported floods, excluding Hazel, by five-year intervals, reveals an increasing number of occurrences and a slight upward trend in the number of floods affecting all land uses, except industrial. A further review of structures flooded shows a slight increase in the extent of residential damage, but little change for other land uses. Substantial flooding problems have been associated with small rural towns and rural townships adjacent to major urban centres.

It is estimated that about 6-7% of the total land area in urban municipalities* throughout Ontario is

**Based on a sample of 33 communities with most having populations greater than 5,000 and all exposed to some risk of flooding.*

presently considered to be flood plain and approximately one-third of this urban flood plain is developed. More than 50% of this total acreage of urban flood plain is found in Metropolitan Toronto, the Region of Peel, London and Brantford.

3. Flood Risk

A CORNERSTONE of any flood plain management policy is the selection of the amount of risk to life and property that is acceptable to society. In practice, this means determining how severe a flood society should be protected against.

The frequency of occurrence of a storm (and/or a snow melt) with given characteristics, and the flood which results from it, are related. A much greater area normally would be flooded and more damage would result from the type of storm that could be expected, on the average, once every 100 years than one that could be expected every 25 years. However, the relationship between the amount of rainfall from a storm and the flooding that results is neither simple or obvious. Intensity of rainfall, size of drainage basin, terrain characteristics, soil types, per-cent vegetative cover, extent of wetlands and swamps for water retention and many other factors all contribute to the degree of flooding.

For flood plain management purposes, the flood plain is normally defined as the area flooded as a result of a storm of an expected frequency. In areas where a major "regional" storm, such as Timmins or Hazel, has been experienced, it may be chosen as a storm against which flood protection is sought.

Two types of storm create the greatest rainfall in Ontario. The first are decadent tropical storms such as Hurricane Hazel, while the second are thunderstorms such as the Timmins. A study of tropical storms shows that 25 hurricanes either passed over or came close to Ontario from 1900 to 1970; eight of these were of extraordinary severity because of high winds and excessive rainfall. Hurricane Hazel was the largest of these 25 tropical storms. The Timmins type of storm could have been centred anywhere in Ontario with the possible exception of the extreme northern part.

Hurricane Hazel and the Timmins storm did not produce the greatest total rainfall that could be

TABLE I
Rainfall Expected from Various Storms*

DESIGN STORM	RAINFALL
1 In 100 year Storm.....	3.4**inches
Timmins Storm.....	5.0 inches
Hurricane Hazel.....	7.1 inches
Probable Maximum Tropical Storm.....	11.8 inches
Probable Maximum Thunderstorm.....	16.1 inches

**Six-hour rainfall over typical 10-square mile watershed.
**Will vary from watershed to watershed.*

expected to occur in Ontario. If Hurricane Agnes (1974) had continued on to Ontario from Pennsylvania, the province could have expected up to a total of 18 inches of rainfall over a five-day period.

The greatest rainfall that Ontario could expect would result from the maximum probable tropical storm or thunderstorm. The concept of maximum probable storm assumes that factors which contribute to heavy rainfall occur in combination in one area at one point in time.

Table I indicates the relative amount of rainfall that could be expected over a six-hour period, from various types of storms.

It can be seen that the Hazel and Timmins storms are considerably more severe than the one in 100 year storm, but considerably less severe than the maximum probable tropical or thunderstorm which could occur. Again, it must be realized, however, that the relationship between storm precipitation, resulting flood flows and flood elevations are complex and, for example, a 10% increase in flood flows will normally result in less than a 10% increase in flood elevation.

Heavy spring runoff accompanied by a major rainfall, or heavy spring runoff alone, tend to be the dominant cause of flooding in Ontario. Flooding due to ice jams or sewer backups is also quite significant throughout the province.

The relationship between risk, defined by the design storm, and the level of damage that could be expected to occur, can vary greatly depending on the physical characteristics and the type and intensity of development in the watershed under consideration. The relationship between long-term average annual expected damage resulting from the adoption of various design criteria in one 89-acre residential area of one particular watershed is shown in Table II.

Table II also indicates that, without any protection, damages per acre in the event of floods of various frequencies are: \$17,791 from Hazel; \$6,768 from the one in 100 year flood, \$3,101 from the one in 50 year flood, and \$1,240 from the one in 25 year flood.

Reductions in damages can be realized by application of either corrective measures such as channelization or by zoning which controls development in the flood plain. Greater damage reductions result from more stringent criteria. It also should be noted that slightly less damage results with zoning, based on a particular flood, as compared with channelization designed to contain the same flood. The reason for this difference is that flood flows exceeding the capacity of the altered channel will ultimately occur and will cause damage to adjacent developments.

Greater per-acre damages than those expressed in Table II apply when correspondingly more intense residential, commercial, institutional and/or industrial developments are located in the flood plain. Other variations in damages per acre can be associated with differences such as those related to valley slopes or soil types.

The choice of a one in 100 year flood frequency as the design criterion for all Ontario would reduce the over-all area defined as flood plain when compared to the Hazel or Timmins criterion. The extent of a reduction in area depends on watershed characteristics* but a survey of three different types of watershed, together with results from a demonstration model, indicates a reduction of about 30% to 50%. A further reduction of the design flood from a one in 100 to a one in 50 year flood would reduce the area defined as flood plain a further 5% to 20%, but also would double the risk of such a flood occurring.

**The adoption of the 1 in 100 year flood criterion may not reduce the area defined as flood plain in cases of very small, large watersheds.*

TABLE II
Direct Flood Damages¹ on a Selected Residential Area² of 89 Acres

DESIGN FLOOD	Long Term Average Annual Damages With Protection Against Design Flood By Zoning (dollars per acre)	Long Term Average Annual Damages With Protection Against Design Flood By Channelization (dollars per acre)	Damages in the Event of the Design Flood Assuming No Protection (dollars per acre)
1. Hurricane Hazel Flood ³	12	17,791
2. 1 In 100 year Flood	31	40	6,768
3. 1 In 50 year Flood.....	70	77	3,101
4. 1 In 25 year Flood.....	116	120	1,240
No Protection.....	216	216	

¹Direct damage to structure and contents. Estimates should be increased by approximately 15% to account for indirect damages to residential property.

²Assuming 100% of the 89 acres is residentially developed. A density of 5 units per acre is assumed and individual units are typical mass-produced (non-luxury) detached houses with basements. Maximum depth of flooding is 3 feet. No back-up of flood waters due to bridges or roads is assumed to exist.

³Assumed to be the 1 in 500 year flood for calculation purposes.

FIGURE II. Alternatives for Reducing Flood Losses

MAJOR TYPES OF ALTERNATIVE	MAJOR ADVANTAGES	MAJOR DISADVANTAGES
1. COMPREHENSIVE LAND USE PLANNING-IMPLEMENTED THROUGH OFFICIAL PLANS AND ZONING BYLAWS	<ul style="list-style-type: none"> . Reduces risk of large scale damage by keeping high risk developments out of flood prone areas . Does not require large capital investments 	<ul style="list-style-type: none"> . Time and cost of preparation . Amendments can quickly reduce effectiveness of original plans and policies . Capital losses can occur to individuals owning land designated as flood prone
2. FLOOD PLAIN REGULATIONS, SANITARY AND HEALTH REGULATIONS	<ul style="list-style-type: none"> . Prevents risk of large scale damage . Does not require large scale capital investments . Normally not as susceptible to pressure for amendments, once implemented 	<ul style="list-style-type: none"> . Flood plain regulations require accurate flood line mapping . If uniformly applied, some communities become relatively less attractive for development . Capital losses can occur to individuals owning property designated as flood plain . Can be costly and difficult to administer
3. FLOOD PROOFING-BUILDING CODES AND REGULATIONS SPECIFY DESIGN AND CONSTRUCTION METHODS THAT WILL PROTECT BUILDINGS FROM LIMITED FLOODING, MAY INVOLVE FILLING AND ELEVATING NEW STRUCTURES. MAY ALSO INCLUDE EMERGENCY METHODS - e.g. SAND BAGGING	<ul style="list-style-type: none"> . Places the major burden of protection on those who benefit . Allows some increase in the degree of development permitted in the flood plains 	<ul style="list-style-type: none"> . Only economically feasible when flooding is to a shallow depth with low velocity . Requires the development and administration of detailed building codes and regulations
4. CONSTRUCT DAMS AND STORAGE RESERVOIRS	<ul style="list-style-type: none"> . Provide protection to existing developments . Permits development where risk would otherwise be prohibitive 	<ul style="list-style-type: none"> . Society as a whole bears costs while flood plain users enjoy major benefits . Very expensive, only justifiable in the cases of very high value developments and the presence of suitable reservoir sites . Reservoirs often require considerable amounts of land . May cause ecological problems - decreased water quality, siltation . Can create false sense of security
5. CONSTRUCT DYKES, LEVEES, FLOOD WALLS	<ul style="list-style-type: none"> . Provides localized protection . Can be constructed at relatively low initial cost . Useful measure against frequent but relatively minor flooding 	<ul style="list-style-type: none"> . Requires use of valuable land . Can hold water back and cause increased upstream damage . Any structure will reduce the natural capacity of valleys to store flood water. Downstream flooding may also be increased . High maintenance cost . High damages can occur when structures are overtopped
6. CHANNEL IMPROVEMENTS - e.g. DREDGING, OR STRAIGHTENING	<ul style="list-style-type: none"> . Provides localized protection . Improves capacity of channel to pass flood waters . Small land requirements, effects of construction are localized 	<ul style="list-style-type: none"> . May create higher velocities and more erosion at low flows; results in deposition of sediments downstream . Expensive utility relocations may be required

- | | | |
|---|--|---|
| <p>7. WATERSHED TREATMENT -
e.g. TREE PLANTING, PRE-
VENTION OF ICE JAMS, PRE-
SERVATION OF NATURAL
FLOOD STORAGE AREA SUCH
AS SWAMPS, REDUCTION OF
PAVED AREAS</p> | <ul style="list-style-type: none"> . Reduces erosion and sedimen-
tation and maintains capacity
of stream to carry flood flows . Can reduce downstream haz-
ards both by reducing flood
water due to runoff and by
reducing debris carried by
flood waters | <ul style="list-style-type: none"> . Individual landowners pay costs -
everyone benefits . Limited effectiveness, particularly in
small watersheds |
| <p>8. FLOOD FORECASTING AND
WARNING SYSTEMS,
EVACUATIONS</p> | <ul style="list-style-type: none"> . Can reduce threat to life -
allows some protection of
moveable property | <ul style="list-style-type: none"> . Only feasible in large watersheds
where floods develop relatively slowly |
| <p>9. PUBLIC DISASTER RELIEF
AND REHABILITATION
FUNDS</p> | <ul style="list-style-type: none"> . Reduces financial burden on
affected individuals | <ul style="list-style-type: none"> . Such expenditures are largely sub-
sidies from all taxpayers to users of
the flood plain . As long as public relief appears to be
available, individuals often fail to
adapt to the hazard |
| <p>10. FLOOD INSURANCE</p> | <ul style="list-style-type: none"> . Alerts residents to risk of being
in flood plain . Can be used where protective
structural methods are not
feasible or during transition
period when old land use
practices are phased out | <ul style="list-style-type: none"> . No private company will underwrite
- government must become involved . Premium would be so high that most
flood plain users would not voluntarily
purchase insurance without govern-
ment subsidy . Difficult to establish the risk for
specific properties |

In summary, approximately 6-7% of urban land is presently defined as flood plain, roughly 4-5% would be defined as flood plain under a uniform one in 100 year flood criterion, and roughly 3-4% would be defined as flood plain under a uniform one in 50 year flood criterion.

The federal government and most foreign countries use one in 100 year flood as the minimum criterion.

One of the greatest problems in flood plain management is the public's inaccurate perception of flood hazard. Even when given technically correct information, most people are unable to anticipate how they would personally be affected by a future flood. Past events such as Hurricane Hazel or the 1974 Grand River Flood have not appeared to appreciably increase the accuracy of the hazard perception of flood plain users in the affected areas. Studies have shown that a large percentage of flood plain dwellers are unaware of any hazard whatsoever.

Two widespread misconceptions are associated with such terms as the one in 100 year flood and the regional flood. A one in 100 year flood is often thought as occurring only once every one hundred years—this is incorrect. Such a flood occurs once every hundred years on the average, but it can occur more than once during a particular 100-year time period. It has a 62% chance of occurring during any particular 100-year period and a 39% chance of occurring during the 50-year expected life span of a building.

A popular misconception related to the application of the regional storm, such as Hazel in 1974, is the belief that areas designated as flood plain should correspond to those areas actually flooded during

Hazel. This is also incorrect. The application of Hazel as the design flood to a particular area requires the assumption that the storm of Hazel's characteristics would be centred in that area. In many instances, the regional flood is in excess of historical floods, in particular watersheds; hence, the extent of the flood plain is judged by some to be excessively large.

4. Flood Plain Management

—Alternatives for Flood Damage Reduction

THE main alternative means of reducing flood losses, along with their advantages and disadvantages are listed in Figure II. The major means of modifying the susceptibility of individuals to floods is through land-use planning and other regulatory measures. Such measures either don't permit developments which would face a high risk, or else specify the precautions that should be taken during design and construction. Land-use planning and flood plain regulations can be implemented in Ontario through existing mechanisms including Official Plans and zoning bylaws under The Planning Act and construction and fill regulations under The Conservation Authorities Act. When this approach is employed, the need for large capital expenditures for corrective measures, such as dams or dyking or for large scale land acquisition, is minimized. The major disadvantages of these measures are the time and cost of developing and administering them.

Corrective measures, such as construction of dams, reservoirs, dykes, channel improvements, and other structures, can modify the effect of a flood on existing and proposed developments. Unfortunately, most of these "structural" alternatives require large capital expenditures that can only be justified in a limited number of situations. Experience with excessive reliance on structural, remedial measures indicates that damage can increase as new development is lured into the flood plain, misunderstanding the flood risk which remains.

In addition to these two major classes of alternatives, flood losses can be reduced by a number of other means such as purchase of flood plain lands for open space, flood insurance, and flood forecasting systems. Each of these measures, however, has disadvantages which limit its widespread, practical application in Ontario.

The selection of the optimum mix of measures to reduce flood losses in a particular watershed is not a simple task. It is highly dependent on the physical characteristics of the watershed, its existing development, and its expected future development.

5. Existing Legislation and Policy

THE main legislative basis for flood plain management in Ontario is found in The Planning Act and The Conservation Authorities Act. The Planning Act is under the jurisdiction of the Minister of Housing, while The Conservation Authorities Act is under the jurisdiction of the Minister of Natural Resources.

The Conservation Authorities Act and The Planning Act have a complementary historical relationship. Both Acts have objectives related to flood control and the regulation or restriction of uses of flood plain lands.

Under Section 27 (1) of The Conservation Authorities Act, authorities may pass regulations which prohibit or regulate the construction of buildings in areas susceptible to flooding during a regional storm. The "regional storm" is defined as Hurricane Hazel, Timmins storm, or the one in 100 year flood, depending upon the location in the province. Regulations limiting the dumping of fill anywhere where it may contribute to flooding can also be enacted under The Conservation Authorities Act. A standard provision in construction and fill regulations states that a Conservation Authority may permit, in writing, the construction of any building or structure or the placing or dumping of fill as long as such action does not affect flooding or pollution.

The general policy related to The Conservation Authorities Act is to restrict new developments in flood plains that would reduce the normal storage and flow capacity of the valley and consequently increase the threat of either upstream or downstream flooding. In cases where development pressures are high, where only shallow flooding can be expected, where little additional upstream or downstream flooding damage will result, where remedial works are

impractical and where no other development opportunities are available, more intensive forms of development are sometimes considered. However, such development is normally considered contingent upon the condition that buildings be flood proofed* up to a height which would provide protection against the regional flood. Structural measures, such as reservoirs and dykes, are employed when their cost can be economically justified in terms of reduction in damage to existing development.

The Planning Act provides the Minister of Housing with the authority to approve all municipal Official Plans and plans of subdivision. An Official Plan is defined under the Act as a program and policy designed to secure the health, safety, convenience and welfare of the inhabitants of an area. Flooding, as well as drainage, are items considered in such a plan.

The Planning Act also requires that plans of subdivision take into account the health, safety, convenience and welfare of future inhabitants, and . . . conservation of natural resources and flood control.

In addition, Section 35 (1) of The Planning Act permits municipalities to pass zoning bylaws for prohibiting the erection of any class of building or structure that may be subject to flooding.

The manner in which Official Plans include policies for flood plain regulations varies widely. Some merely provide the more traditional statements outlining the development limitations of such lands. Others provide a detailed description of the policy constraints of such lands under a very broad designation such as "hazard land". Hazard lands may include areas of poor drainage, flood susceptibility, organic soils, steep slopes, unstable soil, etc. Many municipalities have simply identified the appropriate conservation authority as responsible for regulating fill and construction within the flood plain. Agriculture, conservation, horticulture, forestry, public or private parks, golf courses and similar types of open space activities usually are the permitted land uses.

Another approach for incorporating flood plain considerations into Official Plans is through the adoption of a policy for conservation lands. This approach allows for potential development of such lands after they have been subject to analysis based on specific criteria. This approach also implies a high degree of co-ordination and sophistication for both the local municipality and the conservation authority and is, in reality, the beginning of a development control process for individual applications.

The most sophisticated local approach involves including comprehensive environmental policy within the Official Plan. Such policy serves to establish general principles for flood plain management and clearly identifies the role of all provincial and local agencies in watershed management. This approach

*Flood proofing measures range from structural modifications through installation of special equipment or material to operation and management safeguards such as reinforcing of basement walls, permanent sealing of all exterior openings, elevation of flood vulnerable utilities, installation of sump pumps, etc. The common term "flood proofing" is somewhat misleading. A more correct term would be "flood damage reduction".

also requires the close co-operation and involvement of the local conservation authority.

It is estimated that roughly 80% of the total acreage of urban flood plains in Ontario is covered by flood or fill regulations under The Conservation Authorities Act and/or some type of municipal zoning which recognizes the flood hazard. Estimating the percentage of flood plain protected by some type of municipal zoning is extremely difficult because the flood plain may be included in one of several more inclusive classifications such as hazard lands or open space. In few cases do areas defined as flood plain under Conservation Authority Regulations exactly correspond to areas designated as flood prone in municipal plans.

The only flood proofing which is being enforced in Ontario is effected through a system of permits associated with the fill and construction regulations of the conservation authorities. This only can occur when registered lines are in place. The current practice is that, as a condition for approval, the conservation authority may require the property owner to incorporate flood proofing measures into the design of a structure.

The authority concerning the control and regulation of land use development in the flood plain is delegated to municipal councils under The Planning Act, while the power to control, prohibit, and regulate the use of the flood plain is conferred to a local conservation authority under The Conservation Authorities Act. Unfortunately, the similarity of responsibilities delegated by these two Acts can be the source of some confusion, particularly in respect to which agency has the final right to control flood plain land use. Misunderstanding is greatest where areas are designated under the construction and fill regulations of the local conservation authority but are not included in areas having similar restrictions under the Municipal Official Plan and zoning bylaws. Where this situation occurs, co-ordination of the issuance of building permits by the municipality and fill and construction permits by the conservation authority can be difficult and may be confusing to the public.

Much of this confusion probably is related to the fact that the term flood plain is not specifically referred to and defined in both The Conservation Authorities Act and The Planning Act. On one hand The Conservation Authorities Act refers to land susceptible to flooding during a "Regional Storm". The Regional Storm is further defined in various Ontario Regulations made under the Act according to a schedule of rainfall intensities in a certain sized watershed area. On the other hand, The Planning Act refers to land subject to flooding and to low-lying and marshy lands.

Another area of possible confusion at a more general level may exist in regard to status of the Official Plan of the municipality versus the watershed plan of the local conservation authority.

6. Development Pressure on Flood Plains

At least some pressure for development in urban flood plains is felt throughout the province. The bulk of this pressure, however, appears to exist in central and southwestern Ontario.

A review of the sources of development pressure indicates that about one-half comes from private landowners, one-third from small developers, and most of the remainder from large developers. Pressure from small private landowners is often the most intense as they have definitely fixed site boundaries and limited design potential. Larger developers have professional staff who understand the risk associated with development in the flood plain and, because of larger holdings, often have more flexibility in adopting site designs which avoid flood prone areas. Particularly intense pressure is seen where some development has occurred and attempts at in-filling and/or redevelopment are occurring.

7. Effectiveness of Present Management Policies

It is difficult to provide a simple evaluation of the success of flood plain management policies in Ontario. It can be observed that more than 75% of present development in urban flood plains took place prior to 1950. Furthermore, only a slightly increasing trend towards higher flood damage exists.

Major channelization and reservoir construction projects undertaken by conservation authorities on watersheds such as the Thames, Grand, Humber and Don, undoubtedly have reduced risk to existing developments. Also, the involvement of conservation authorities in land-use planning and the adoption of construction and fill regulations have limited the rate of encroachment of new developments in flood plains.

No systematic evaluation of the effectiveness of Official Plans has been made and no statistics are available about the amount of flood prone land presently being managed through Official Plans. It can be observed, however, that amendments to planning legislation were made after the Hazel flood of 1954 and these amendments permitted the prohibition of certain land uses in low-lying land. Since these amendments were enacted, renewed effort has been made by municipal planners to ensure that developments do not take place in the flood plain.

As part of the study, an opinion survey was sent by the consultants to selected provincial and municipal planners, resource managers, engineers, developers, local mayors, reeves and regional chairmen. A majority view from the survey was that a review of

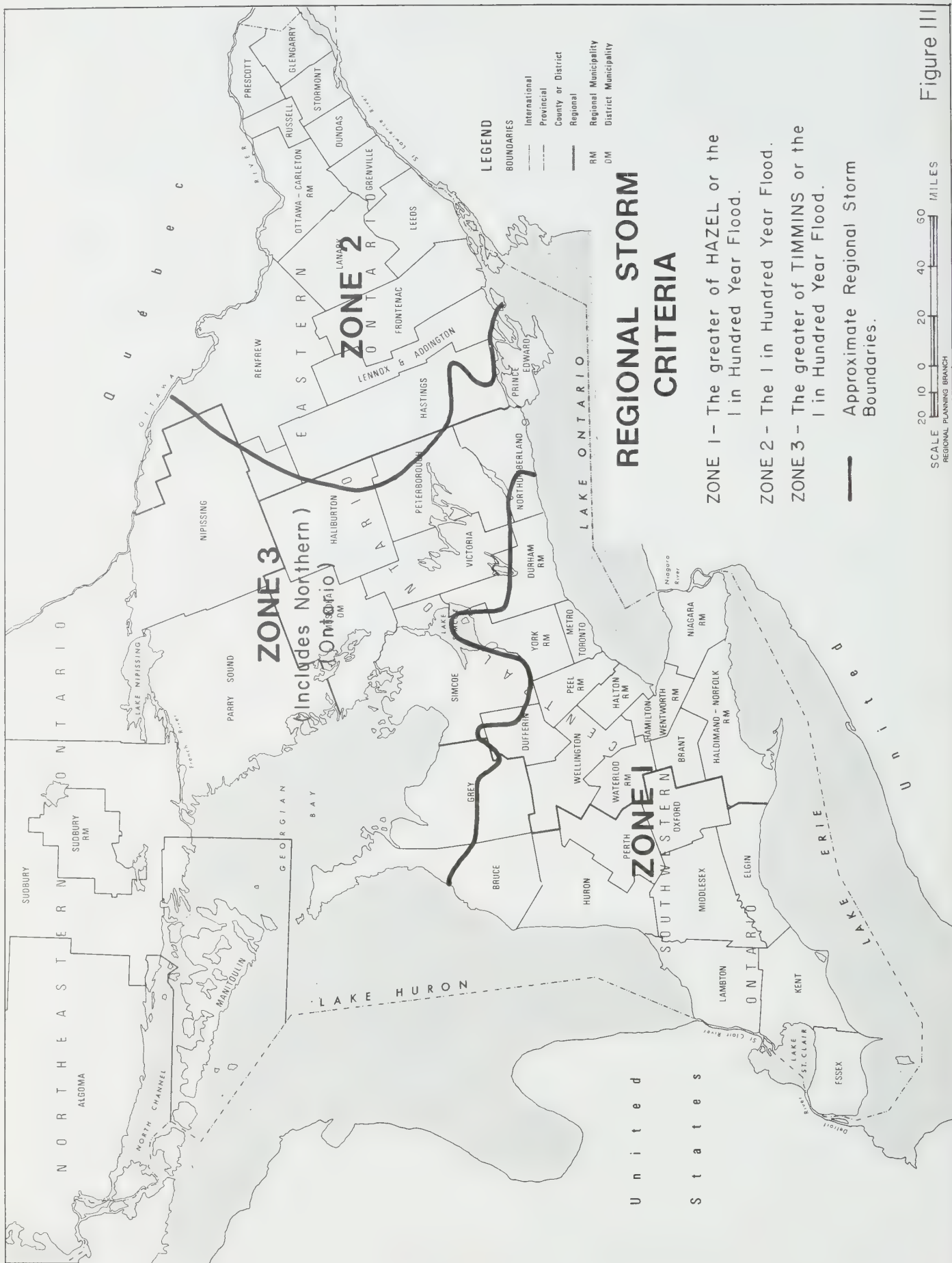


Figure III

present policy is in order and that the acceptability of any particular development in flood prone areas should be based on flood risk and damages considering:

- (1) Expected flood damage to the particular development;
- (2) Technical and economic feasibility of flood proofing;
- (3) Amount of interference with normal flood flow (i.e. increase in upstream and/or downstream flooding); and
- (4) Expected depth of water during design flood.

Such a response implies that more flexible, yet more sophisticated and complex, system of evaluation for development proposals is desired.

8. Alternative Flood Plain Criteria

At least three basic questions must be answered before any comprehensive flood plain management policy can be developed and implemented;

- (1) How severe a flood should society be protected against?
- (2) Should varying degrees of risk of damage within individual flood plains be recognized?
- (3) Should flood plains in all urban areas be treated in the same manner or should "special cases" be recognized?

A. Levels of Risk

The following is a description of alternative levels of risk which could be used to determine the extent of flood plains in Ontario, together with the main pros and cons of adopting each alternative.

(i) PROBABLE MAXIMUM FLOOD

The probable maximum flood is the largest flood that, theoretically, could be expected to occur on a given stream at a selected point in time. Determination of this flood is based on a consideration of the chances of simultaneous occurrence of the maximum of several elements or conditions that contribute to a flood; for example, largest expected rainfall, maximum intensity of rainfall, and previously saturated or frozen soil conditions. The concept of a probable maximum flood usually is applied to the design of spillways at large dams where a failure may create a dam breakaway many times more severe than a natural flood. No examples are given in the literature of the probable maximum flood being used to define flood plains for the purposes of zoning. The probable maximum flood is well in excess of present criteria used to define flood plains in Ontario. Its adoption would lead to a very significant increase in the area defined as flood plain, but would provide the ultimate in flood protection.

PROS: (1) A very low risk of loss of life or damage to property would exist.

- (2) Once new flood lines were defined, legal and technical administration of flood plain regulations would be relatively simple.
- (3) Increase in open space and other non-intensive land uses could be expected in some urban areas due to an increase in areas defined as flood plain.

CONS: (1) Would severely restrict areas for intensive development in many communities.

- (2) Revised zoning and fill and construction regulations could cause significant capital losses for owners of additional urban areas defined as flood plain.
- (3) Cost of required flood plain mapping would be high and would take several years to complete since all existing mapping in the province would have to be revised.

(ii) RETAIN EXISTING ONTARIO CRITERIA—"REGIONAL STORM CONCEPT"

The existing criteria are shown on the attached map. Flows from a Hurricane Hazel type storm or the one in 100 year flood, whichever is greater, are used in Central and Southwestern Ontario; the one in 100 year flood is used in Eastern Ontario; and flows from a Timmins type storm or the one in 100 year flood, whichever is greater, are used in Northern Ontario. (See Figure III)

PROS: (1) Recognizes that floods from known historical storms can create higher peak flood flows in some sections of the province than others.

- (2) Technical and legal administration is relatively simple.
- (3) Much of the required flood plain mapping is completed and, to varying degrees, existing flood plains are recognized in Municipal Official Plans.

CONS: (1) Relatively restrictive to further development in a number of communities.

- (2) The regional storm concept is particularly difficult for the public to understand.
- (3) The risk of recurrence of Hurricane Hazel or the Timmins Storm cannot be determined accurately.

(iii) A UNIFORM ONE IN 100 YEAR FLOOD ACROSS THE PROVINCE

PROS: (1) Would reduce area defined as flood plain central, southwestern, and northern Ontario, and this permit more intensive urban development in these areas. In three selected watersheds and through use of a demonstration model, it was known that the flood plain defined under the "one in 100 year" flood criterion was 30-50% less than the area defined as flood plain under the Hazel or Timmins flood criterion. Therefore, the adoption of the

“one in 100 year” criterion would reduce the area of urban flood plains from the present 6-7% to approximately 4-5% of all urban land.

- (2) A single criterion would be more easily understood.

- CONS:
- (1) Risk of such a flood occurring is relatively high; that is, 39% in any 50-year period or 62% in any 100-year period.
 - (2) Development pressures in areas that would no longer be considered flood plain would probably result in a reduction in open space and other non-intensive land uses in some communities.
 - (3) Does not recognize the more severe flooding that has resulted in certain areas of the province from historical storms such as Timmins or Hazel.
 - (4) Relatively sophisticated engineering techniques are required to accurately delineate floodlines in the many watersheds which lack historical flood flow records.
 - (5) Higher flood levels caused by increased encroachment could increase the severity of flooding now experienced by present flood plain users.

(iv) A UNIFORM ONE IN 50 YEAR FLOOD ACROSS THE PROVINCE

- PROS:
- (1) An additional 5-20% reduction from the area defined as flood plain under the one in 100 year flood. Another 1-2% of urban lands would be available for intensive development (as compared to the one in 100 year flood criterion).

- (2) A single criterion would be more easily understood.

- CONS:
- (1) A reduction of the design flood from a one in 100 to one in 50 would double the risk factor.
 - (2) Does not recognize the more severe flooding which has been experienced in all areas of the province.
 - (3) Development pressure on areas that no longer would be considered flood plain would probably result in a substantial reduction in open space in many communities.
 - (4) Relatively sophisticated engineering techniques are required to accurately delineate floodlines in the many watersheds which lack historical flood flow data.
 - (5) Higher flood levels caused by increased encroachment could increase the severity of flooding now experienced by present flood plain users.

B. One Versus Two Zones of Flood Plain

Once a design flood criterion is selected and the flood plain defined, a decision can be made to either apply consistent zoning regulations across the entire flood plain or to relate regulations specifically to risk of damage expected in different areas of the flood plain.

In Ontario, the normal practice is to apply uniform regulations across the entire flood plain. This practice is called the “one-zone” approach. A “two-zone” or “floodway – flood fringe” approach is used in many of the American States. With such a system, the floodway is defined as the area of the flood plain required to pass the deep, fast-flowing flood water, while the fringe is the peripheral area flooded to a depth of a few feet. Development is severely restricted in the floodway while limited development is permitted in the flood fringe, provided buildings are flood proofed to a height beyond the level expected during the design flood. The extra protection provided by flood proofing above the design flood is required to compensate for the reduction in the normal storage and flow capacity of the valley, resulting from the building, and to take into account the danger of floating debris.

Many variations in the two-zone concept exist with most of the variation related to how the floodway is distinguished from the flood fringe. One way of demarcating the two zones would be on the basis of expected flood frequency. For example, the floodway could be based on the one in 100 year flood and the fringe on the one in 200 year flood. Another way would be to define the floodway on the basis of maximum historical flood in the specific watershed and to define the fringe on the basis of the regional flood.

The most widespread application of the two-zone concept in Ontario has been in the Grand River watershed. It also has been introduced in a limited number of other areas such as Chatham and Wallaceburg.

The major advantages and disadvantages of these two approaches are listed below:

(i) ONE-ZONE SYSTEM

- PROS:
- (1) Only one flood plain needs to be determined and mapped;
 - (2) Less confusing, easier to define and administer;
 - (3) Little or no increase in upstream or downstream flooding associated with a given design flood can be expected if development controls are applied uniformly across the entire flood plain.

- CONS:
- (1) Poorly relates level of restriction to degree of risk within the flood plain;
 - (2) Can reduce the range of land uses acceptable in the periphery of the flood plain.

(ii) TWO-ZONE SYSTEM

- PROS:
- (1) More flexible; better relates level of restriction to degree of risk;

- (2) Permits a greater degree of development in the flood plain with little increase in risk of damage;
- (3) Once implemented, it gives the landowner in the fringe greater certainty in use of his land and reduces the need for obtaining technical expertise for proposed developments in the flood plain.

- CONS: (1) Two flood plains must be determined and mapped.
- (2) Some difficulty may be encountered in defining the "floodway – flood fringe" according to floods of an expected frequency, particularly if streams are not gauged and if historical records of flows are not available.
 - (3) Requires incorporation of flood proofing requirements into building codes. Flood proofing requirements which limit subdivision design are not always popular.
 - (4) Increased flood levels upstream and downstream may occur due to reduction in normal storage and flow capacity of the valley may occur unless the floodway is defined properly.

C. Special Cases

Another choice that inevitably must be made in the development of flood plain management policy is whether or not to provide special status to communities adversely affected by a uniform policy of flood plain regulation, such as those long established in the flood plain.

Alternatives could include:

(i) DO NOT RECOGNIZE SPECIAL CASES

- PROS: (1) Consistent, does not encourage domino effect associated with making a few exceptions;
- (2) Ensures no increase of risk of flooding upstream or downstream from a given community.

- CONS: (1) Would severely restrict the future growth of some communities.

(ii) DEFINE SPECIAL CASES BY A SINGLE CRITERION

- PROS: (1) Simple to administer, once a criterion is selected.

- CONS: (1) No one measure can accurately incorporate the relationships among downstream and upstream flooding effect, need for growth of community, etc.

- (iii) DEFINE SPECIAL CASES BASED ON SEVERAL CRITERIA (Such as to Per Cent of Municipality in Flood Plain, Expected Growth, Upstream and Downstream Flooding Effects, Cost of Structural Alternatives)

PROS: (1) Would better reflect unique situations.

- CONS: (1) Would be difficult to get agreement on which factor to include and how such factors should be weighted.

Which flood criterion should be selected, whether to select the one- or two-zone concept, and which position to take regarding special cases, are all controversial questions. Therefore, it is not surprising that little widespread agreement exists about which combination of answers to these questions provides the best approach to flood plain management. The final selection of an approach must be ultimately the result of a careful weighing of all the PROS and CONS associated with the 24 approaches which can be developed from combining the alternatives presented above, as well as many others which also could be developed.

9. Prerequisites for Improved Flood Plain Management

FEEDBACK from the opinion survey indicated a number of ways and means of improving the management of flood plains in Ontario. Many of these recommendations would appear to apply, no matter which combination of alternative criteria is selected.

- (1) The need for improved communication between provincial and municipal agencies, as well as among engineers, planners, and administrators.
- (2) The need for better educating the general public and developers about flood hazards.
- (3) The need for trained personnel to enforce flood plain regulations.
- (4) The need for complete, accurate, and up to date flood line mapping for all urban municipalities.
- (5) The need to establish comprehensive planning guidelines for individual watersheds.
- (6) The need for developing the capability to more accurately predict flood flows for individual watersheds.
- (7) The need for areas defined as flood prone in zoning bylaws and Official Plans to coincide with areas defined as flood plains under regulations of The Conservation Authorities Act.

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